Interest Rates Determination and Crisis Puzzle (Empirical Evidence from the European Transition Economies)

Rajmund Mirdala

Faculty of Economics, Technical University in Kosice, Slovak republic

December 2012

Interest Rates Determination and Crisis Puzzle
(Empirical Evidence from the European Transition Economies)

Rajmund Mirdala
Faculty of Economics, Technical University of Kosice, Slovakia
rajmund.mirdala@tuke.sk

Abstract:

Economic theory provides clear suggestions in fixed versus flexible exchange rates dilemma in fighting high inflation pressures. However, relative diversity in exchange rate regimes in the European transition economies revealed uncertain and spurious conclusions about the exchange rate regime choice during last two decades. Moreover, eurozone membership perspective (de jure pegging to euro) realizes uncertain consequences of exchange rate regime switching especially in the group of large floaters. Successful anti-inflationary policy associated with stabilization of inflation expectations in the European transition economies at the end of 1990s significantly increased the role of short-term interest rates in the monetary policy strategies. At the same time, so called qualitative approach to the monetary policy decision-making performed in the low inflation environment, gradually enhanced the role of real interest rates expectations in the process of nominal interest rates determination. However, economic crisis increased uncertainty on the markets and thus worsen expectations of agents.

In the paper we analyze sources of nominal interest rates volatility in ten European transition by estimating the structural vector autoregression (SVAR) model. Variance decomposition and impulse-response functions are computed to estimate the relative contribution of inflation expectations and expected real exchange rates to the conditional variability of short-term money market interest rates as well as responses of nominal interest rates to one standard deviation inflation expectations and expected real interest rates shocks. Effects of economic crisis are considered by estimation of two models for every single economy from the group of the European transition economies using data for time periods 2000-2007 and 2000-2011.

Keywords: interest rates, inflation expectations, expected real interest rates, SVAR, variance decomposition, impulse-response function

JEL Classification: C32, E31, E43, E52

1. Introduction

Macroeconomic stability, fast recovery from deep and sudden transition shock and real output growth stimulation represents one of the most challenging objectives for the European transition economies in the early 1990s. Consistent choice as well as flexible adjustments of monetary policy framework and exchange rate regime accompanied key crucial economic policy decisions in this process. Associated changes in monetary-policy strategy reflected wide range of macroeconomic aspects underlying sustainability of appropriate exchange rate regime choice.

Among key determinants of the exchange rate regime choice in the European transition economies at the beginning of the 1990s we may consider an effort to regain macroeconomic stability, foreign exchange reserves requirements and availability, overall external economic (trade and financial) openness, etc. At the later stages of transition process we emphasize the role of massive foreign capital inflows, sustainability of real economic growth, institutional adjustments according to perspectives of ERM2 entry.

Initial transition shock followed by the sharp real output decline associated with intensive inflation pressures (caused by rapid exchange rate devaluations, price liberalization and deregulation, tax reforms, fiscal imbalances, etc.) emphasized a crucial importance of strong nominal anchor for monetary authorities in restoring a macroeconomic stability and confidence as well as positive expectations of economic agents. However immediate exchange rate based stabilization became an appropriate strategy only for countries with adequate foreign exchange reserves while being able to significantly reduce inflation pressures in adequate (short) time period to prevent undesired rapid overvaluation. As a result it seems to be convenient to divide the European transition economies in two groups (so called "peggers" and "floaters") considering initial exchange rate regime framework.

Economic theory provides clear suggestions in fixed versus flexible exchange rates dilemma in fighting high inflation pressures. However, relative diversity in exchange rate regimes in the European transition economies revealed uncertain and spurious conclusions about the exchange rate regime choice during last two decades. Moreover, eurozone membership perspective (de jure pegging to euro) realizes uncertain consequences of exchange rate regime switching especially in the group of large floaters.

Successful anti-inflationary policy associated with stabilization of inflation expectations in the European transition economies at the end of 1990s significantly increased the role of short-term interest rates in the monetary policy strategies. At the same time, so called qualitative approach to the monetary policy decision-making performed in the low inflation environment, gradually enhanced the role of real interest rates expectations in the process of nominal interest rates determination. However, economic crisis increased uncertainty on the markets and thus worsen expectations (inflation expectations including) of agents.

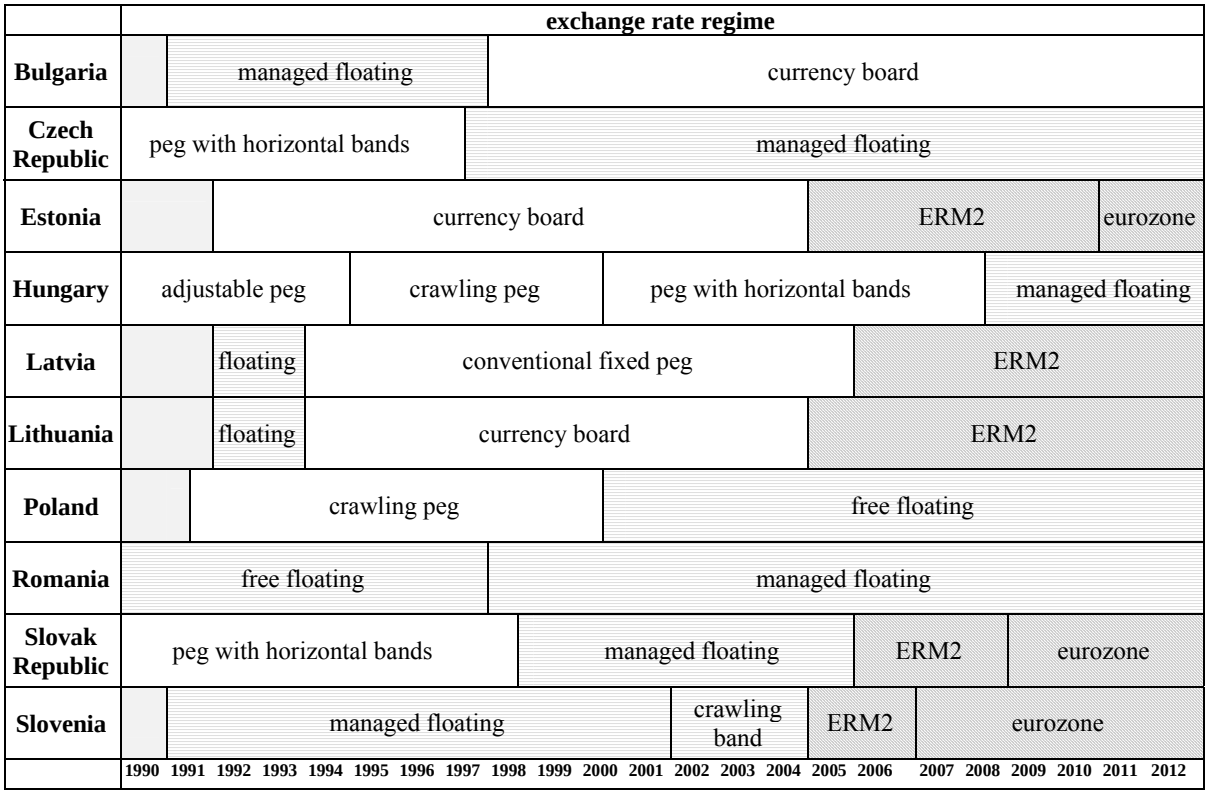
Eurozone member countries as well as global economy are currently exposed to the negative effects of the financial and economy crisis. To alleviate recession and support economic recovery, monetary authorities dramatically reduced key interest rates. Low interest rates together with quantitative easing, however, should not necessarily increase supply of loans due to prudential credit policy of commercial banks reflecting increased uncertainty on the markets. As a result, policy of low interest rates seems to be inefficient.

In the paper we analyze sources of nominal interest rates volatility in ten European transition economies to identify the impact of inflation expectations and expected real interest rates on the nominal interest rates volatility by estimating the structural vector autoregression (SVAR) model. From constructed model we estimate the relative contribution of both determinants to the conditional variability (variance decomposition) of short-term money market interest rates. At the same time we estimate responses (impulse-response functions) of short-term nominal money market interest rates to one standard deviation inflation expectations and expected real interest rates shocks. Effects of economic crisis on our results are considered by estimating two models for every single economy from the group of the European transition economies employing monthly data for two different time periods 2000-2007 and 2000-2011. Comparison of results for both models is crucial for analysis the economic crisis contribution to the nominal interest rates volatility in ten European transition economies.

2. Overview of Exchange Rate Regime Evolution in the European Transition Economies

Exchange rate policy evolution represents one of the key parts of crucial economic policy decisions at the beginning of the transition process in countries from the region of Central and Eastern Europe in the early 1990s. Despite its complexity and particularity there seems to be some similar features at the starting point of transition process in all European transition economies such as recession followed by initial transition shock and common vision of European union and Economic and Monetary union membership.

Table 1 Exchange Rate Regimes in the European Transition Economies



Note: Exchange rate regime evolution in the European transition economies: *Bulgaria* - since 1991 floating (pegged exchange rate regime undesirable due to possible low credibility), currency board since 1997 (after 1996-1997financial crisis (public debt, bad commercial banks loans)). *Czech Republic* - exchange rate pegged to currency basket with narrow but continuously widen horizontal bands, since May 1997 after currency attacks switch to managed floating with no predetermined path for the exchange rate with DEM (EUR) as reference currency. *Estonia* - currency board since 1992 till 2011 (euro adoption), plan to adopt in 2008 but delayed due high inflation, since 2011 eurozone membership. *Hungary* - managed floating till February 1995, since March 1995 till the end of 1999 crawling peg with continuously decreased rate of periodical devaluation and widen horizontal bands, since January 2000 exchange rate pegged to euro combined with wide horizontal bands (since May 2001), since May 2008 managed floating with EUR as reference currency. *Latvia* - since February 1994 exchange rate pegged to SDR (fixing the exchange rate to a basket of currencies (SDR) instead of a single currency serves to promote long-term stability) (since January 2005 pegged to EUR). *Lithuania* - since April 1994 currency board (exchange rate pegged to USD, in February 2002 pegging switched to EUR). *Poland* - since the end of 1991 crawling peg with continuously decreased rate of periodical devaluation and widen horizontal bands, since April 2000 free floating. *Romania* - free floating, since 1998 exchange rate arrangement reclassified as managed floating. *Slovak Republic* - exchange rate pegged to currency basket with narrow but continuously widen horizontal bands, since October 1998 after currency attacks switch to managed floating with no predetermined path for the exchange rate with DEM (EUR) as reference currency, since 2009 eurozone membership. *Slovenia* - managed floating with no predetermined path for the exchange rate (since February 2002 crawling band - the monetary authority manages the float of the domestic currency within certain fluctuating margins around a depreciating path - a heavily-managed crawling band with pragmatic monetary, real, external and financial indicators).

ERM2 - June 2004 - Estonia (left in January 2011 after euro adoption), Lithuania, Slovenia (left in January 2007 after euro adoption)

- May 2005 - Latvia
- November 2005 - Slovak Republic (left in January 2009 after euro adoption)

.***Source:*** IMF AREAER 1990-2011, author's processing.

Macroeconomic stability as one of the primary objectives in the initial phase of the transition process affected exchange rate regime choice in the European transition economies.

However, low credibility of monetary institutions, lack of foreign exchange reserves and high inflation differentials represented real constraints and difficulties related to the sustainability of pegged exchange rate regimes. Brief overview of the exchange rate regimes evolution in the European transition economies provides table 1.

It seems to be clear that the European transition economies did not follow common practice in the process of the exchange rate regime choice at the beginning of the 1990s. Small Baltic countries adopted currency board regime (Estonia and Lithuania) eventually conventional fixed peg regime (Latvia). Hungary adopted crawling peg regime (after few years of adjustable peg in place) together with Poland. Czech Republic and Slovak Republic adopted pegged regime with horizontal bands. Despite high inflation rates Bulgaria, Romania and Slovenia adopted floating exchange rate regime due to low level of reserves and lack of credibility though Bulgaria switched to currency board after 1996-97 financial crisis. It seems to be clear that most of the European transition economies enjoyed disinflationary and credibility benefits of so called hard or soft exchange rate regimes. Fixed exchange rates as the nominal anchor significantly contributed to the successful disinflationary process at the end of the 1990s.

Till the end of the decade many countries from the group switched to more flexible exchange rate regimes (Czech Republic in 1997, Slovak Republic in 1998 and Poland in 2000). Similarly Hungary switched to intermediate regime by widening horizontal bands. Although Hungary stacked to exchange rate pegged to euro, by employing wide horizontal bands de facto followed the same trend as previous group of countries.

Exchange rate regime choice also affected corresponding monetary policy strategy framework. Countries with exchange rate as nominal anchor (hard pegs or soft pegs with narrow horizontal bands) successfully implemented exchange rage targeting. Countries with soft pegs (pegs with wide horizontal bands or crawling pegs) and floating regimes employed monetary targets as intermediate criteria of monetary policy (monetary targeting).

Overall success of disinflationary process represents one of the key milestones on the road to stable macroeconomic environment with crucial role of low and stable inflation expectations. Low inflation combined with stable inflation expectations is considered to be a substantial condition for switching from quantitative (money supply) to qualitative (interest rates) approach in monetary policy decision-making. This adjustment in monetary policy strategies seems to be obvious in the European transition economies since the end of 1990s as a part of prevailing trend in weakening of relationship between money and inflation. Increased role of inflation expectations together with raising credibility of monetary authorities resulted in adoption of direct (explicit) inflation targeting strategy in many European transition economies - Czech Republic (1998), Poland (1999), Hungary (2001), Slovenia (2002), Romania (2005) and Slovak Republic (2005).

European transition economies challenged a decision of a euro adoption and eurozone membership several years before the economic crisis arises. Disputable policy implications of sacrificing monetary sovereignty rose as a crucial assumption affecting main features as well as durability of preparation phase timetable in countries with flexible exchange rate regimes (Czech Republic, Poland, Romania, Slovak Republic and Slovenia). Among a variety of determinants and aspects we emphasize the role of decisions inevitably associated with "right" scheduling of the eurozone entry. Some countries from the group of the European transition economies already joined the eurozone (Estonia (2011), Slovak Republic (2009), Slovenia (2007)) followed by participation of their currencies in ERM2 (Estonia (June 2004), Slovak Republic (November 2005), Slovenia (June 2004)). On the other hand currencies of Lithuania and Latvia are still participating on ERM2.

The loss from sacrificing exchange rates flexibility in the eurozone candidate countries became directly confronted with benefits related to exchange rate stability associated with

sacrificing monetary autonomy. Despite plausible advantages of pegging exchange rates of candidate countries to euro followed by the euro adoption it seems to be clear that risks associated with potential effects of breakdown in mutual interconnections between macroeconomic development and flexible exchange rates leading path seem to be of a minor interest in current empirical literature.

3. Overview of the Literature

Obvious trend in the exchange rate regimes development and low inflation environment, together with increased sensitivity of commercial banks to the interest rates development in the European transition countries in the pre-crisis period during the last decade, enabled monetary authorities to successfully harmonize national monetary policy frameworks with eurozone legal and operative pillars. Exchange rates stability during the preparation phase on the road to euro adoption was clearly associated with capabilities of national monetary authorities to maintain a monetary stability via interest rates transmission channel.

Gradual transition toward implementation of the qualitative approach mechanisms to the monetary policy decision-making in the European transition economies significantly increased the role of short-term interest rates adjustments. Operative fine-tuning of money market interest rates provides crucial information for commercial banks about intentions of monetary authority and thus enhancing signal function of key interest rates. However, desired effects of interest rate changes may be weaken especially in non-stable inflation environment. Sudden inflation shifts may cause misleading interpretation of interest rates adjustments and thus provide spurious signals to agents.

Linkage between inflation and nominal interest rates seems to be well observed. There is a strong interconnection in development of both categories. Traditional channel of impulses transmission provides clear suggestion about causal relationship between inflation and nominal interest rates - changes in the rate of inflation forces changes in the nominal interest rates due to changes in inflation premium. Following this assumption, central banks raises interest rates as the response to the inflation increase (this practice is known as monetary policy rule), trying to stabilize (maintain) purchasing power of the money. On the other hand, inflation increase doesn't necessarily reflect unreasonably fast economic growth signalizing overheating. In such a case, increased interest rates should not contribute to the inflation drop. Therefore, raising inflation is not necessarily associated with fast economic growth, but may be a result of market failures or exogenous shocks and thus affect economies even in the recession or stagnation.

Nominal interest rates are not necessarily determined just by the rate of inflation. It is due fact that nominal interest rates consists of two components - real value of money and inflation premium. As a result, changes in nominal interest rates may be caused not only by forces determining the rate of inflation, but also by a number of variables affecting real interest rates (expectations of agents included). Nominal price of money is determined by a wide variety of determinants, that is why it may not seem to be clear, whether nominal interest rates volatility is caused by changes in inflation expectations or expected real interest rates. Correct identification of (especially short-term) nominal interest rates volatility seems to be a crucial aspect for successful monetary policy decision-making. For example, an increase in the nominal interest rates caused by higher inflation expectations of agents represents a right signal for monetary policy tightening. Corresponding increase in the rate of interest seems to be well suited decision for reduction of excessive inflation pressures. On the other hand, an increase in the nominal interest rates caused by higher expected real interest rates is usually associated with different monetary policy consequences.

Inflation versus interest rates nexus seems to be widely discussed area in the empirical literature. St-Amant (St-Amant, 1996) employed bivariate SVAR model to analyze the impact of expected inflation and ex-ante real interest rates on the nominal interest rates volatility of government bonds with maturity one year and ten years in the U.S.A. Following author's results we may conclude that inflation expectations seems to prevailing determinant of nominal interest rate volatility since the beginning of 1970s till the middle of 1980s, whereas shifts in expected real interest rates substantially contributed to the nominal interest rates volatility during the first half of the 1990s. Deacon a Derry (Deacon a Derry, 1994) provided a variety of methods for identification of market interest rate and inflation premium from the interest rates associated with government bonds. Engsted (Engsted, 1995) implemented cointegration analysis and VAR methodology to examine properties of interest rates and inflation time series. Neely a Rapach (Neely a Rapach, 2008) analyzed time series for real interest rates employing growth equilibrium model. Authors dedicated extra effort to investigate a presence of persistence patterns especially in medium and long time period. Ragan (Ragan, 1995) analyzed time structure of nominal interest rates to estimate inflation expectations of agents. Results of his empirical investigation provided interpretation of the real interest rate volatility over time. Crowder a Hoffman (Crowder a Hoffman, 1996) analyzed mutual interconnections between inflation and interest rates. Implemented SVAR methodology helped authors to isolate permanent and temporary sources of volatility for nominal interest rates and inflation time series. Lai (Lai, 2004) examined properties of time series for real interest rates. Author investigated conditions to maintain a time series stacionarity under changing length of base period. Garcia a Perron (Garcia a Perron, 1996) analyzed long-run features of time series for real interest rates in the U.S.A. Lanne (Lanne, 2002) verified a validity of Fisher effect following the results of lung-run interconnections testing between inflation and nominal interest rates in the U.S.A.

4. Econometric model

Employed methodology to analyze sources of nominal interest rates volatility is based on technique pioneered by Blanchard a Quah (Blanchard - Quah, 1988) who estimated bivariate model with two types of exogenous shocks. To identify structural shocks authors implemented identification scheme based on decomposing effects of the shocks into permanent and transitory components. Long-run identifying restrictions were applied on the variance-covariance matrix of reduced form VAR residuals.

Following our objective we estimate a model consisting of the vector of endogenous variables X_t and the same number of primitive (structural) shocks. Unrestricted form of the model is represented by the following infinite moving average representation:

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + \ldots = \sum_{i=0}^{\infty} A_i\varepsilon_{t-i} = \sum_{i=0}^{\infty} A_i L^i \varepsilon_t \tag{1}$$

or

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{p^e,t} \\ \varepsilon_{ir_r^e,t} \end{bmatrix} \tag{2}$$

where X_t is a vector of the endogenous macroeconomic variables, A_i is a polynomial variance-covariance matrix of lag-length l, L is lag operator and ε is a vector of identically normally distributed, serially uncorrelated and mutually orthogonal white noise disturbances (vector of reduced form shocks in elements of X). Vector X_t of the endogenous variables of

the model $\left(X_t = \left[ir_{n,t}, p_t\right]\right)$ consists of the following two elements: nominal interest rates $\left(ir_{n,t}\right)$ and rate of inflation $\left(p_t\right)$. Vector ε_t of the past primitive shocks is represented by the following two shocks: inflation expectations shock $\left(\varepsilon_{p^e,t}\right)$ and expected real interest rates shock $\left(\varepsilon_{ir_r,t}\right)$.

The structural exogenous shocks from equation (1) are not directly observable (cannot be correctly identified) due to the complexity of information included in true form VAR residuals. As a result structural shocks cannot by correctly identified. It is necessary to transform true model into following reduced form

$$X_t = e_t + C_1 e_{t\text{-}1} + C_2 e_{t\text{-}2} + \ldots = \sum_{i=0}^{\infty} C_i e_{t\text{-}i} = \sum_{i=0}^{\infty} C_i L^i e_t \tag{3}$$

or

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} c_{11i} & c_{12i} \\ c_{21i} & c_{22i} \end{bmatrix} \begin{bmatrix} u_{i^e,t} \\ u_{ir_r^e,t} \end{bmatrix} \tag{4}$$

From equations (1) and (3) we clearly observe relationship between primitive shocks ε_t and reduced form VAR residuals e_t:

$$e_t = A_0 \varepsilon_t \tag{5}$$

Matrices C_i we obtain from estimated equation (1). Considering $A_i = C_i A_0$, we can now identify matrix A_0. To estimate coefficient of matrix A_0, it is necessary to impose four restrictions. Two restrictions are simple normalizations, which define the variance of the shocks $\varepsilon_{p^e,t}$ and $\varepsilon_{ir_r,t}$ (it follows the assumption that each of the disturbances has a unit variance, $\text{var}(\varepsilon) = 1$). Third restriction comes from an assumption that identified shocks are orthogonal. Normalization together with an assumption of the orthogonality implies $A_0^{'} A_0 = \Sigma$, where Σ is the variance covariance matrix of $e_{p^e,t}$ and $e_{ir_r,t}$. The final restriction, which allows the matrix C to be uniquely defined, represents the long-run identifying restriction providing that a cumulative effect of expected real interest rate shock to the nominal interest rates variability is zero:

$$\sum_{i=0}^{\infty} a_{12i} = 0 \tag{6}$$

Long-run identifying restrictions enable us to isolate temporary and permanent sources of nominal interest rates volatility and thus to distinguish effects of both structural shocks on endogenous variables of the model.

In terms of our vector autoregression model it implies

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ . & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{i^e,t} \\ \varepsilon_{ir_r^e,t} \end{bmatrix} \tag{7}$$

Correctly identified model can be finally estimated employing SVAR methodology. Variance decomposition and impulse-response functions are computed to observe a relative contribution of inflation expectations and expected real interest rates shocks to the nominal interest rates conditional variance as well as response of nominal interest rates to one standard deviation inflation expectations and expected real interest rates shocks. Effects of economic crisis on our results are considered by estimation of two models (with data sets for two different time periods 2000-2007 (model A) and 2000-2011 (model B)) for every country from the group of the European transition economies. Comparison of results for both models is crucial for evaluation of the economic crisis contribution to the nominal interest rates volatility in ten European transition economies.

5. Data and Results

To estimate a sources of the nominal interest rates volatility in ten European transition economies (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia) we employ monthly data with period 2000M1-2007M12 (model A) consisting of 96 observations and with period 2000M1-2011M12 (model B) consisting of 144 observations for following endogenous variables - nominal interest rates (interbank offered rates with 3 months maturity[1]) and inflation (core inflation). Estimation of two models corresponds with the primary objective of the paper that is to evaluate effects of inflation expectations and estimated real interest rates on nominal interest rates development considering possible implications of economic crisis on presented results. Time series for all endogenous variables were drawn from IMF database (International Financial Statistics, November 2012). Time series for the rate of inflation were seasonally adjusted.

We also emphasize a relative importance of exchange rate regime choice on the results providing suggestion about potential effects of breakdown in mutual interconnections between macroeconomic development and flexible exchange rates leading path (as one of the key implications after euro adoption). The beginning of the period for time series included in both models is related the continuous strengthening of qualitative features in the monetary policy decision-making since the beginning of the past decade.

Correct estimation of both models and precise identification of exogenous shocks hitting the model it is necessary VAR model to be stationary. To test the stationarity of both models it is necessary to test the time series for unit roots and cointegration. To test the stability of the VAR model we have also applied a number of diagnostic tests of the VAR residuals (normality, serial correlation, heteroskedasticity).

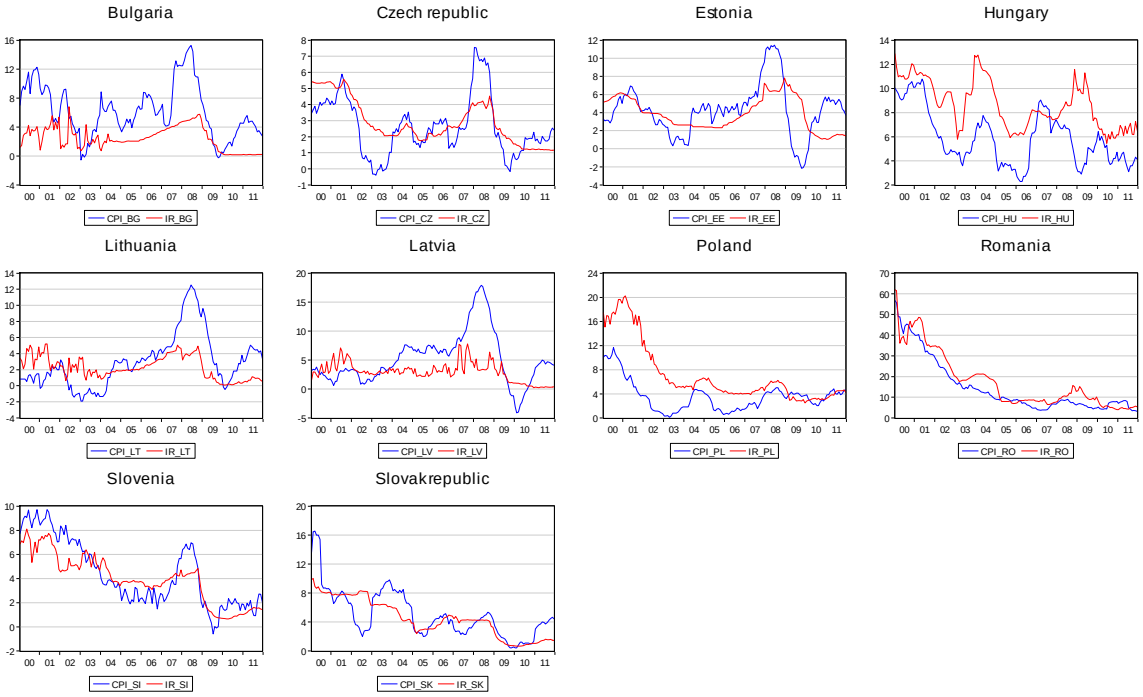
Overview of interest rates and inflation development in the European transition economies provides figure 1. As we have expected, most countries experienced obvious trend in inflation decrease during the first half of the past decade. Adverse impacts of external (oil and gas markets) and internal (seasonal food, indirect taxes) price development together with spurious price effects of euro adoption (in respective countries) and economic crisis contributed to ceasing or slowing down of positive inflation trend in most of countries from the group. On the other hand interest rate development seems to be affected by exchange rate regime choice. Countries with currency board arrangements (Bulgaria, Estonia and Lithuania) and conventional fixed peg (Latvia) experienced relatively stable trend in the interest rates development during the pre-crisis period. In countries with flexible exchange rate

[1] Interbank offered rates in Estonia, the Slovak Republic and Slovenia were replaced by EURIBOR since the eurozone membership.

arrangements[2] interest rates seem to be much more determined by main trends in the development of inflation.

In both groups of countries interest rates did not precisely follow a leading path of inflation. At the same time, adjustments in interest rates seem to be lagged following changes in inflation with up 6 month delay. Countries with hard pegs also experiences repetitive periods with negative real interest rates in the recent years due to excessive inflation pressures.

Figure 1 Interest Rates and Inflation (2000M1-2011M12)



Note: Endogenous variables - inflation (CPI), short-term interest rates (IR) are expressed in percentage.
Source: Compiled by author based on data taken from IMF - International Financial Statistics (November 2012).

Crises period affected interest rates and inflation in all countries. Inflation rates in all ten European transition economies reached its local maximum (for the period of last few years) shortly before negative effects of ongoing economic crisis revealed. Although the rate of inflation seems to differ at the end of pre-crisis period in each individual country, all economies subsequently experienced rapid disinflation as a result of recession. In all countries interest rates adapted to changes in inflation with just moderate intensity causing high volatility and instability of real exchange rates. Moreover, Hungary experienced the period of asymmetric development of inflation and interest rates leading path. Strong divergence effect in Hungary was associated with sharp increase in real interest rates emphasizing crisis related internal and external macroeconomic imbalance in the country.

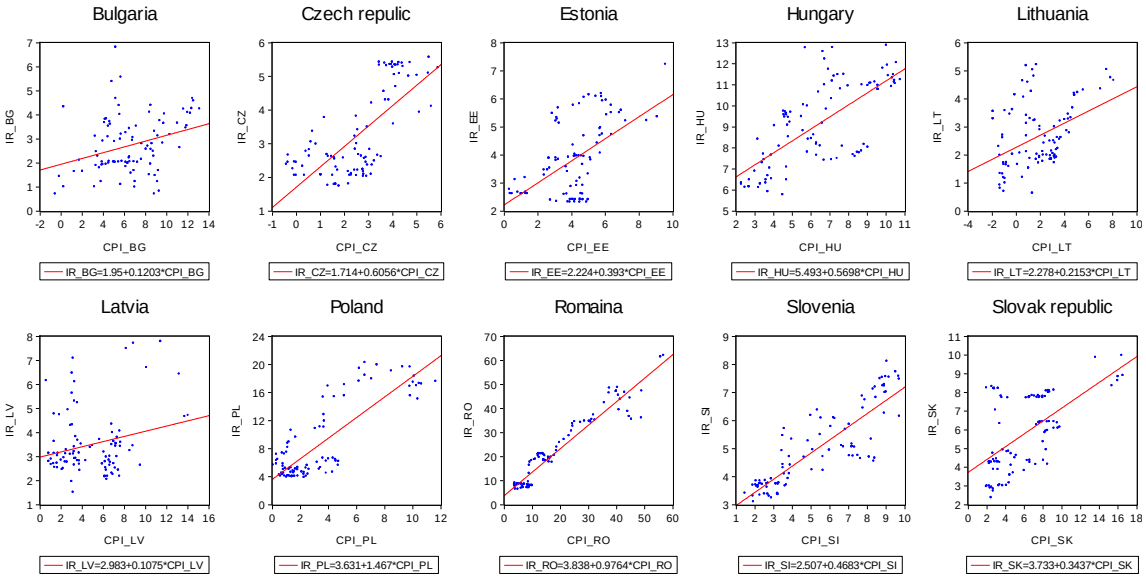
A. Correlation Analysis

Mutual relationship between inflation and interest rates in the European transition economies during the pre-crisis period depicts figure 2. Coefficients of correlation between

[2] Although Hungary employed fixed exchange rate pegged to euro till May 2008, due to wide horizontal bands (±15%) exchange rate floated in de facto flexible exchange rate arrangement.

core inflation and short-term interest rates revealed plausible implications of exchange rate regime choice. In the group of countries so called "peggers" (countries with currency board arrangement or conventional fixed peg with narrow horizontal bands) the coefficients of correlation between inflation and interest rates seem to be lower (in some cases even much lower) than in the group of countries so called "floaters" (countries with free or managed floating or intermediate pegs).

Figure 2 Inflation and Interest rates Correlation Coefficients (2000M1-2007M12)



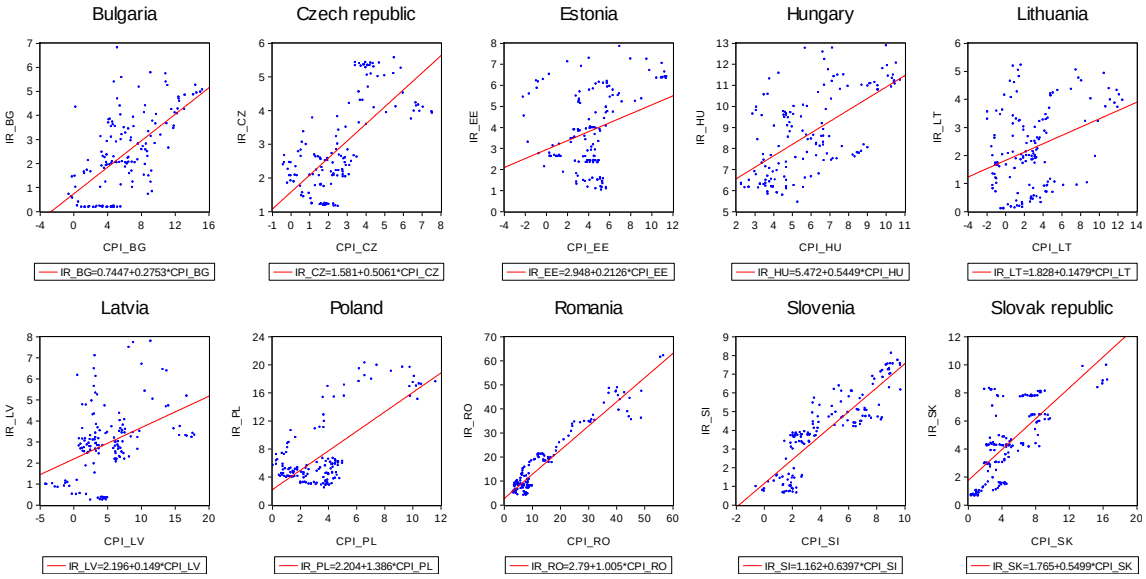
Note: Endogenous variables - inflation (CPI), short-term interest rates (IR) are expressed in percentage. Correlation coefficients between inflation and interest rates: BG (0.310), CZ (0.715), EE (0.556), HU (0.700), LT (0.428), LV (0.235), PL (0.825), RO (0.957), SI (0.864), SK (0.595).
Source: Author's calculations.

Following the results of correlation analysis we may conclude that in countries with exchange rate as the nominal anchor, non-autonomous monetary policy is obviously associated with low interest rates (irrespective of inflation) while exchange rate target contributes to successful disinflation process. On the other hand interest rates leading path doesn't seem to be directly affected by domestic rate of inflation proving a substantial source of real exchange rate volatility. Even though, stabilized expectations of agents due to exchange rate targeting significantly contributes to the overall macroeconomic stability.

Countries with inflation targeting and no predetermined path for the exchange rate achieved higher correlations between interest rates and inflation especially due to increased flexibility of short-term interest rates. In such countries, autonomous monetary policy obviously contributes to higher mutual interconnections between the rate of interest and the rate of inflation. Signal function of interest rates adjustments seems to be more significant and thus providing more precise information to agents about the price stability associated with the overall macroeconomic performance of the country.

Mutual relationship between inflation and interest rates in the European transition economies during the extended period depicts figure 3. Coefficients of correlation between core inflation and short-term interest rates revealed curious effects of the crisis period.

Figure 3 Inflation and Interest rates Correlation Coefficients (2000M1-2011M12)



Note: Endogenous variables - inflation (CPI), short-term interest rates (IR) are expressed in percentage. Correlation coefficients between inflation and interest rates: BG (0.621), CZ (0.677), EE (0.334), HU (0.616), LT (0.351), LV (0.404), PL (0.704), RO (0.955), SI (0.871), SK (0.714).
Source: Author's calculations.

Economic crisis significantly affected results of correlation analysis between inflation and interest rates. It seems that the strength of mutual interconnections between both categories weakened in most of countries from the group irrespective of the exchange rate arrangement. Increased uncertainty on the markets resulted in drop of information value resulted from associated changes in prices especially due to exogenous character of prices related initial determinants causing decreased efficiency of allocative efficiency of the markets. Lower predictability of inflation trend during the recession together with higher discretion in the monetary policy decision-making following the principle of low interest rate policy and quantitative easing that monetary authorities implemented to fight a crisis, contributed to higher volatility in the real exchange rates development in most of the countries from our group. The only exception in the group of "peggers" we found in two countries with currency board arrangements - Bulgaria and Lithuania and in the group of "floaters" - Slovak republic (country joined eurozone in 2009).

Despite decreased interconnection between interest rates and inflation development during the extended period, coefficients of correlations between both categories remained, in general, higher in the group of "floaters". Moreover, overall decrease in correlation coefficients doesn't seem to be significant in this group of countries. Spurious effects of the crisis period seem to be more evident in the group of "peggers" considering much more significant changes in the coefficients of correlation between the rate of inflation and short-term interest rates.

Summarizing overview for correlation analysis of mutual relationship between inflation and interest rates in the European transition economies in the pre-crisis and extended period provides table 2.

Table 2 Summary of Correlation Analysis for Pre-crisis and Extended Period

	2000-2007	2000-2011	Δ
Bulgaria	0.310	0.621	↑
Czech Republic	0.715	0.677	↓
Estonia	0.556	0.334	↓
Hungary	0.700	0.616	↓
Latvia	0.428	0.351	↓
Lithuania	0.235	0.404	↑
Poland	0.825	0.704	↓
Romania	0.957	0.955	=
Slovak Republic	0.595	0.714	↑
Slovenia	0.864	0.871	=

Source: Author's calculations.

B. Unit Root Test

Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were computed to test endogenous variables for the presence of a unit root. Results of unit root tests are summarized in the table 3 (detailed results of unit root are not reported here to save space. Like any other results, they are available upon request from the author).

Table 3 Unit Root Tests

Country	**Model**	**Order of integration of endogenous variables**			
		CPI		**IR**	
		ADF	PP	ADF	PP
Bulgaria	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Czech Republic	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Estonia	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Latvia	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Lithuania	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Hungary	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	**I(0)**	I(1)
Poland	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	**I(0)**	I(1)	I(1)
Romania	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Slovak Republic	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Slovenia	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)

Source: Author's calculations.

Both ADF and PP tests indicate that all variables are not stationary on the values so that the null hypothesis of a unit root cannot be rejected for any of the series (with exception of interest rates in Hungary (ADF, model B) and inflation in Poland (PP, model B). Testing variables on the first differences indicates that the time series are stationary. Ve may conclude that all variables are I(1).

C. Cointegration Test

Because endogenous variables have a unit root on the values it is necessary to the test the time series for cointegration using the Johansen and Juselius cointegration test. The test for cointegration was calculated using three lags as recommended by AIC (Akaike Information Criterion) and SIC (Schwarz Information Criterion). Results of cointegration tests are summarized in the table 4 (detailed results of cointegration tests are not reported here to save space. Like any other results, they are available upon request from the author).

The results of the Johansen cointegration tests confirmed the results of the unit root tests for both models (models A and B) in all ten countries providing that any linear combination of two variables is nonstationary process. Trace statistics and maximum eigenvalue statistics (both at 0.05 level) in each individual country indicated that there is no cointegration among endogenous variables of both models.

Table 4 Johansen and Juselius Cointegration Tests

Country	Number of cointegrating equations			
	Model A		Model B	
	trace stat.	max eigvalue stat.	trace stat.	max eigvalue stat.
Bulgaria	0	0	0	0
Czech Republic	0	0	0	0
Estonia	0	0	0	0
Latvia	0	0	0	0
Lithuania	0	0	0	0
Hungary	0	0	0	0
Poland	0	0	0	0
Romania	0	0	0	0
Slovak Republic	0	0	0	0
Slovenia	0	0	0	0

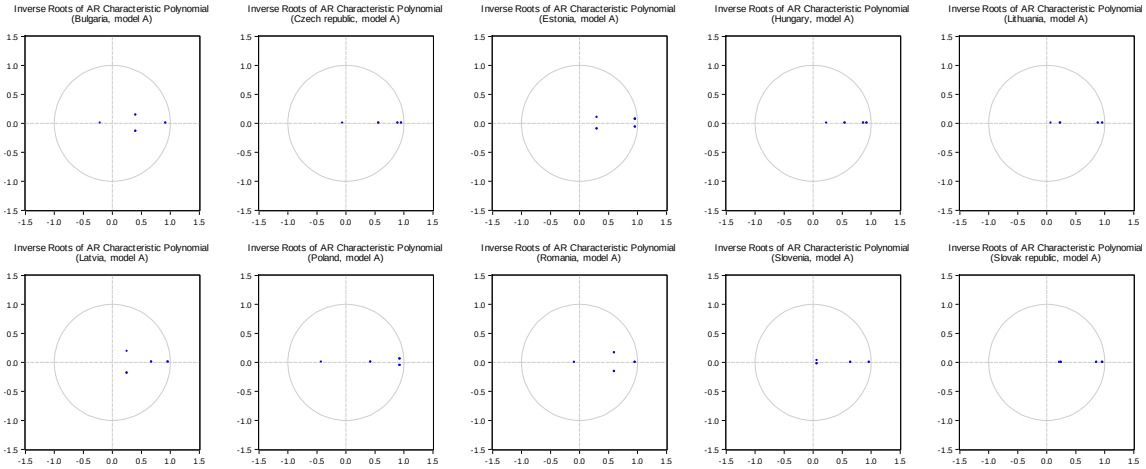
Source: Author's calculations.

D. VAR Stability

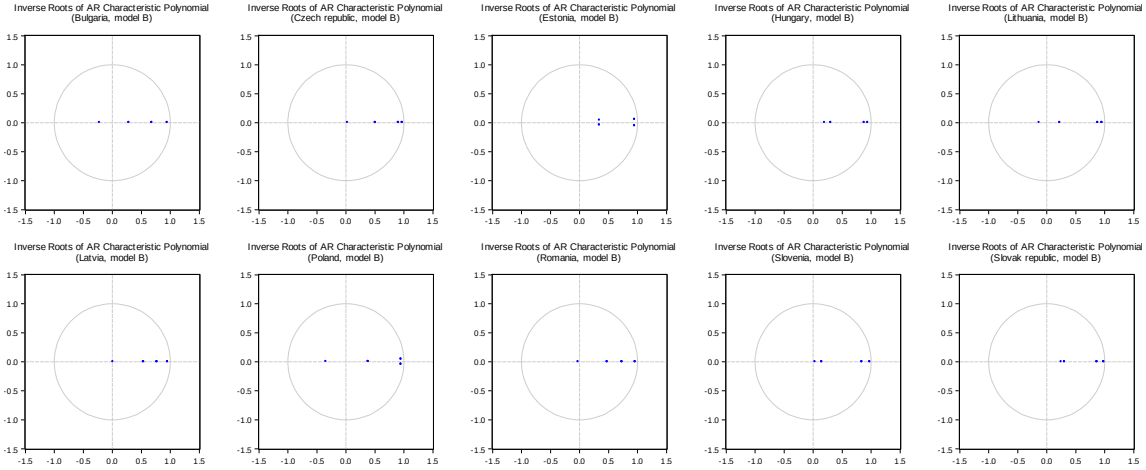
To test the stability of VAR model we also applied a number of diagnostic tests. We found no evidence of serial correlation, heteroskedasticity and autoregressive conditional heteroskedasticity effect in the disturbances. Model also passed the Jarque-Bera normality test, so that errors seem to be normally distributed. VAR models seem to be also stable because inverted roots of the model for each country lie inside the unit circle (figure 4).

Figure 4 VAR Stability Condition Check

Model A



Model B



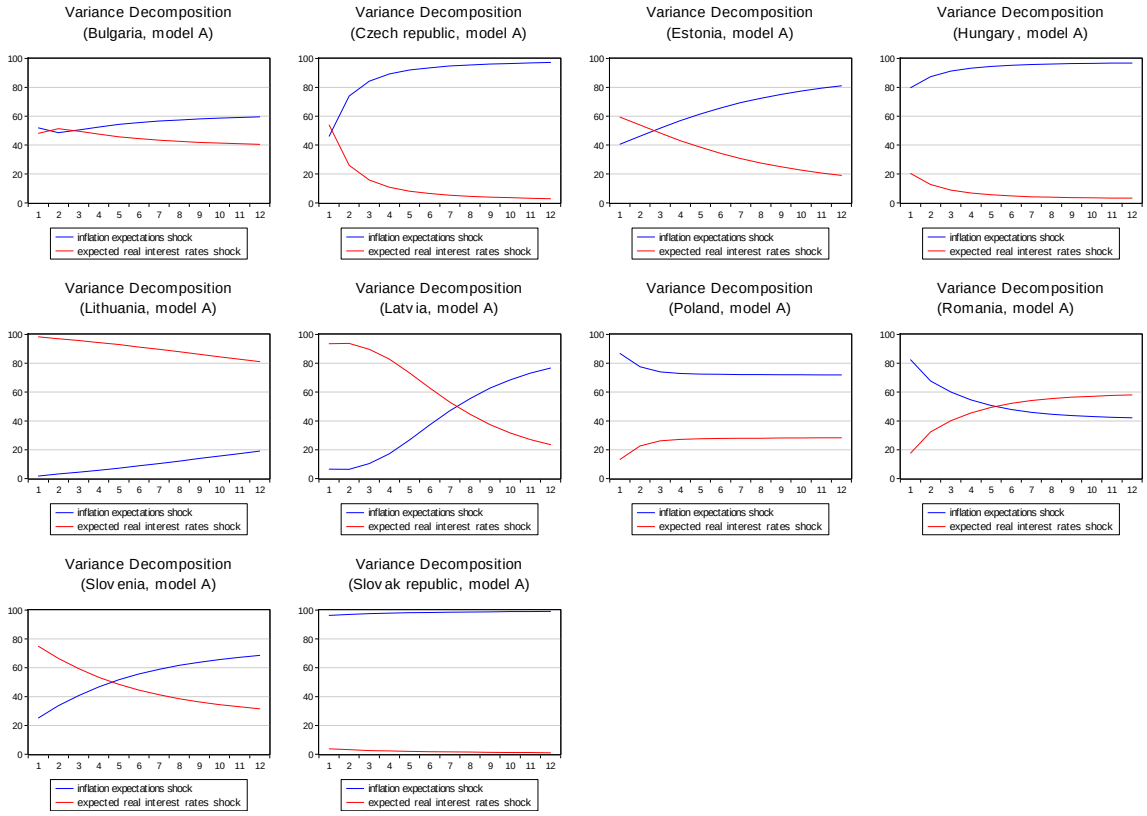
Source: Author's calculation.

Following results of the unit root and cointegration tests we estimated both models using variables in the first differences so that we can calculate variance decompositions and impulse-response functions for all ten countries from the group of the European transition economies. Following the main objective of the paper we summarize the relative importance of inflation expectations and expected real interest rates shocks in the nominal interest rates conditional variance. We also analyze individual responses of nominal interest rates to the positive one standard deviation inflation expectations and expected real interest rates shocks. Effects of the crisis period on sources of the nominal interest rates volatility in the European transition economies is observed by comparing the results for estimated models employing time series for two different periods - model A (2000M1-2007M12) and model B (2000M1-2011M12).

E. Variance Decomposition

Figure 5 shows the estimated contribution of inflation expectations and expected real interest rates shocks to nominal interest rates conditional variance in the European transition economies during the pre-crisis period (2000M1-2007M12) in model A.

Figure 5 Variance Decomposition of Nominal Interest Rates (2000M1-2007M12)



Source: Author's calculations.

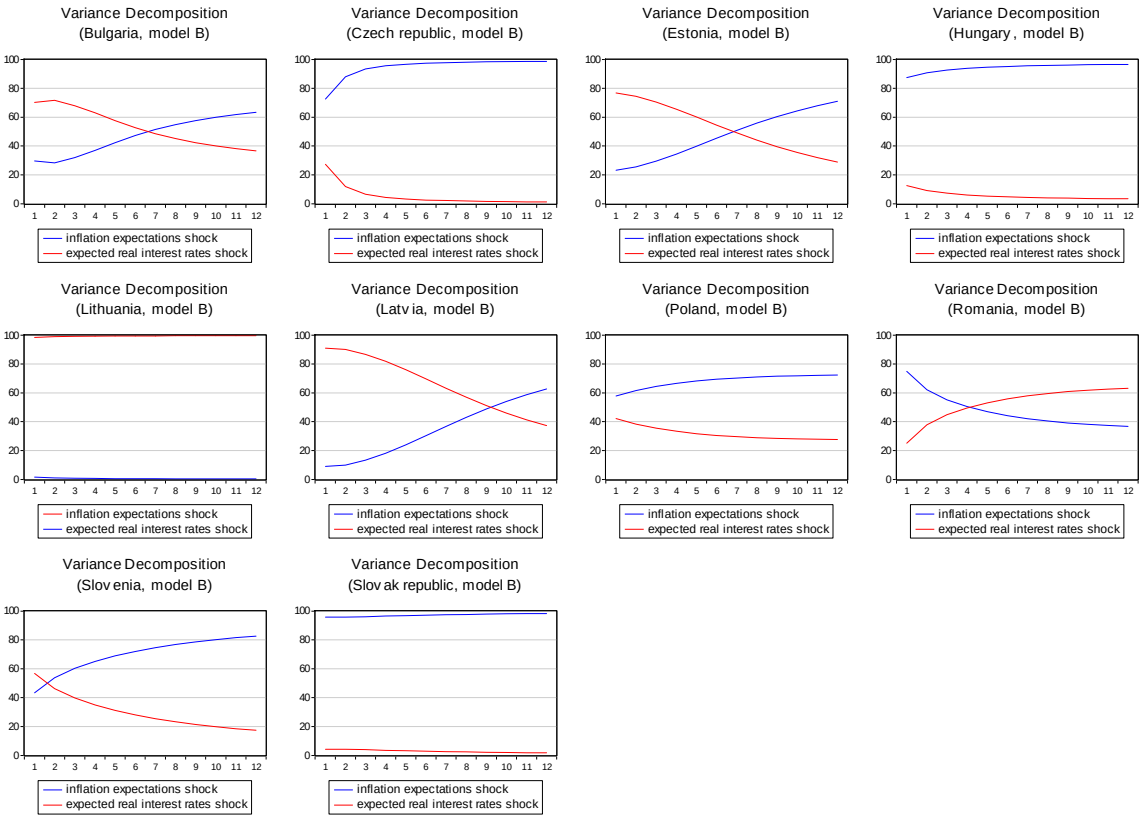
Overview of structural shocks contributions to the nominal interest rates unpredicted shifts revealed remarkable implications of the exchange rate regime choice. Immediate contribution of the expected real interest rates shock is significantly higher in countries with currency board arrangement (Bulgaria, Estonia, Lithuania) and conventional fixed peg (Latvia) though the size of initial contribution differs in all four economies. It seems like exchange rate as the nominal anchor contributes to the stability of inflation expectations (especially in the short-run). Exchange rate targeting thus provides a suitable vehicle for reducing short-run effects of inflation expectations on the price mechanism on the money market. Higher contribution of expected real interest rates to the nominal interest rates variance also reduces distorting effects of money markets imperfections resulting from false price signals related to sudden inflation shifts. It also seems to be obvious that the relative contribution of the expected real interest rates shock decreases over time followed by increasing role of the inflation expectations shock.

The relative immediate importance of the expected real interest rates shock in the group of countries, so called floaters, seems to be significantly smaller reflecting crucial role of inflation expectations in determining the nominal interest rates leading path (with exception of Slovenia). Despite the absence of apparent nominal anchor (explicit exchange rate target

with no predetermined path for the exchange rate), explicit inflation targeting (monetary policy strategy implemented by all six countries with floating exchange rate regimes during the first half of the 2000s) delivered similarly successful results in disinflation process. Thus, a substantially higher role of the inflation expectations in this group of countries seems to be reasonable. The overall impact of inflation expectations on interest rates even rises in the long-run (with exception of Poland and Romania).

Figure 6 shows the estimated contribution of inflation expectations and expected real interest rates shocks to the nominal interest rates conditional variance in the European transition economies during the extended period (2000M1-2011M12) in model B.

Figure 6 Variance Decomposition of Nominal Interest Rates (2000M1-2011M12)



Source: Author's calculations.

In general, economic crisis predominately confirmed main character of identified potential sources determining the short-term nominal interest rates volatility in the European transition economies. In the group of countries, so called "peggers" we experienced an increased immediate contribution of expected real interest rates shock to the conditional variability of nominal interest rates. Even the price effects of economic crisis seem to be spurious and hardly predictable, immediate role of inflation expectations in determining nominal interest rates generally decreased in this group of countries. It seems that a credible nominal target operating as a key pillar of the monetary policy strategy provides a crucial anchor for stable inflation expectations of agents, especially in the short-run.

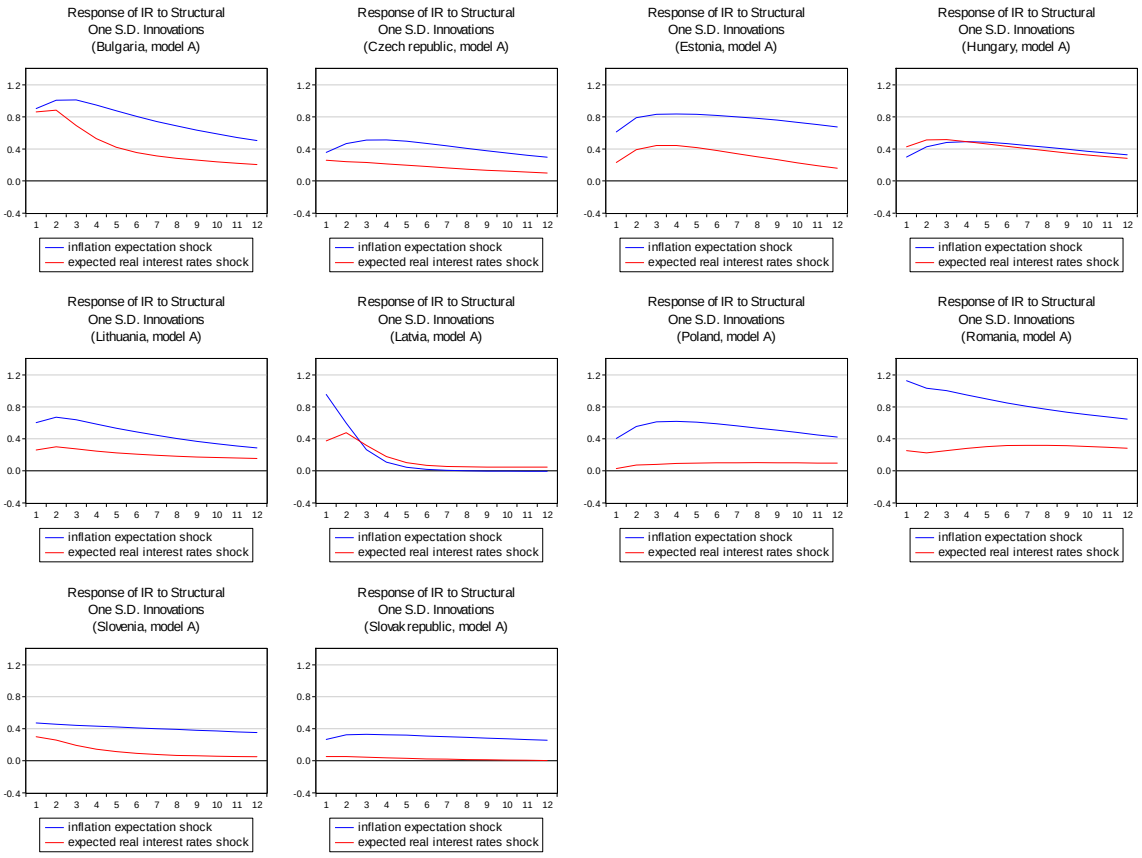
In the group of countries, so called "floaters", immediate contribution of inflation expectations shock to the nominal interest rates variance predominately increased (with exception of Poland and Romania in the short-run). Despite overall success of inflation

targeting we suggest that inflation expectations tend to suffer from low level of self-persistence and become quite vulnerable to sudden changes caused by unexpected exogenous shocks. Related nominal interest rates volatility and associated real interest rates instability reflects relatively low success of monetary authority to regain price stability providing the absence of a credible nominal anchor.

F. Impulse-Response Function

In the figure 7 we summarize responses of nominal interest rates to one standard deviation positive inflation expectations and expected real interest rates shocks in the European transition economies during the pre-crisis period (2000M1-2007M12) in model A.

Figure 7 Impulse-Response Functions of Nominal Interest Rates (2000M1-2007M12)



Source: Author's calculations.

Nominal interest rates responded to both inflation expectations and expected real interest rates shocks during pre-crisis period in line with empirical expectations. One standard deviation positive shock of inflation expectations caused immediate increase in nominal interest rates in all ten European transition economies. On the other hand we observed some differences in intensity as well as durability of the effect.

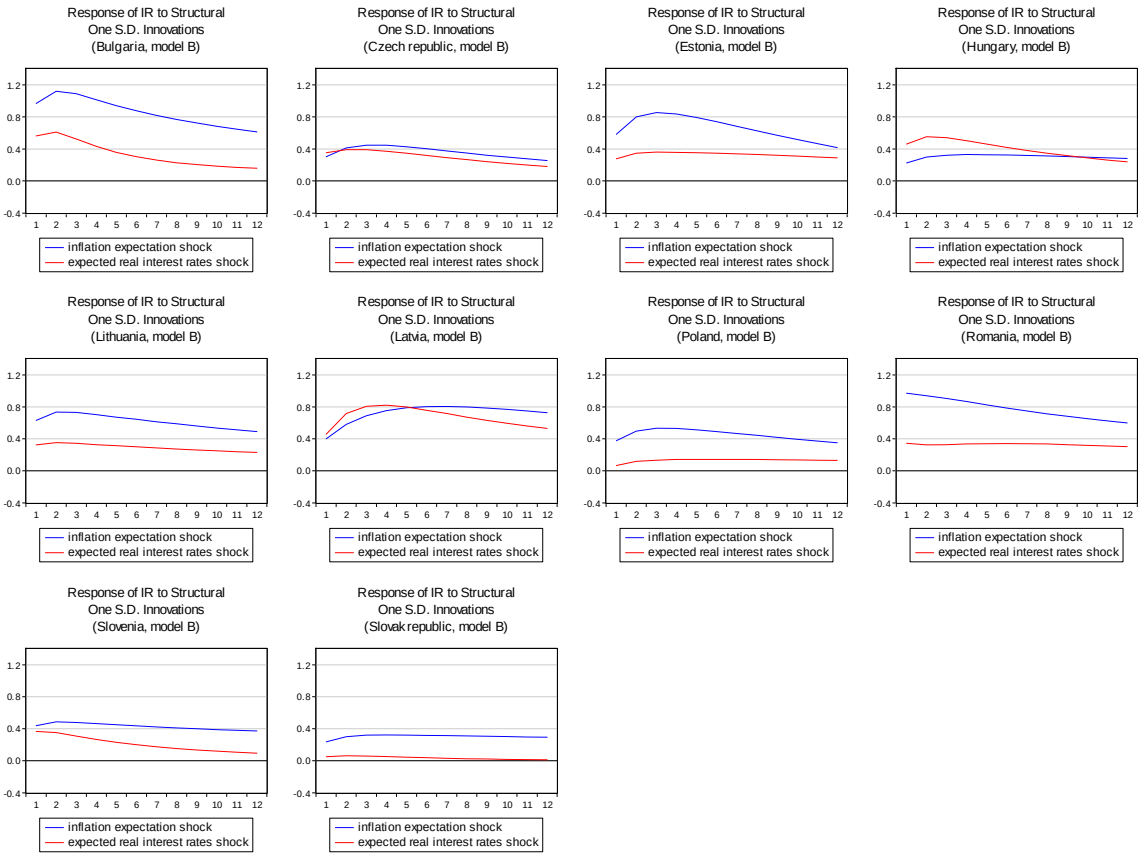
Immediate response of nominal interest rates to unpredicted sudden positive one standard deviation real interest rate shock in the group of countries, so called "peggers" as well as in Hungary, seems to be noticeably higher. Provided that Hungarian forint operated

during the pre-crisis period in the intermediate exchange rate regime[3], similarity of results seems to be convenient.

Effects of both shocks seem to be just temporary in determining short-time variability of nominal interest rates. Negative impact of inflations expectations and expected real interest rates shocks steadily died out confirming long-run neutrality of nominal interest rates to their effects.

In the figure 8 we summarize responses of nominal interest rates to one standard deviation positive inflation expectations and expected real interest rates shocks in the European transition economies during the extended period (2000M1-2011M12) in model B.

Figure 8 Impulse-Response Functions of Nominal Interest Rates (2000M1-2011M12)



Source: Author's calculations.

Crisis period affected responses of nominal interest rates to positive inflation expectations and expected real interest rates shocks with spurious results. In three countries from the group of so called "peggers" (Bulgaria, Latvia and Lithuania) we experienced slight increase in the durability of the negative effect imposed by the inflation expectations shock. An exception in this group of countries is Estonia (anticipated eurozone membership might cause changes in effects of inflation expectations). At the same the negative effect of expected real interest rates shock seems to be durable in all countries of so called "peggers" with

[3]Hungarian forint operated during pre-crisis period in de facto fixed peg regime, but due to substantial range for fluctuations provided by wide horizontal bands it was included in the group of countries, so called "floaters".

expectation of Bulgaria. At the same we experienced an increased durability of the expected real interest rates shock in Estonia and Latvia.

Changes in effects of inflation expectations shock on the nominal interest rates during the extended period in the group of so called "floaters" seems to be just negligible. At the same time we experienced a slight increase in durability of expected real interest rates positive shock (especially in Czech Republic and Poland).

6. Conclusion

Exchange rate regime choice in the European transition economies affected corresponding monetary policy strategy framework. Countries (peggers) with exchange rate as the nominal anchor (hard pegs or soft pegs with narrow horizontal bands) successfully implemented exchange rage targeting. Countries (floaters) with soft pegs (pegs with wide horizontal bands or crawling pegs) and floating regimes employed monetary targets as intermediate criteria of monetary policy (monetary targeting) later (continuously since the end of the 1990 in respective countries) followed by adoption of direct (explicit) inflation targeting.

Regular monetary policy anchors operates well as stabilizing pillars under turbulent conditions in domestic (open) economy considering relative stability on the markets of main trading partners as well as of the country providing nominal anchor (i.e. exchange rate). Following our results in the model with time series for pre-crisis period it seems that exchange rate as the nominal anchor contributed to the stability of inflation expectations in the group of countries, so called "peggers" (especially in the short-run). Exchange rate targeting thus provided a suitable vehicle for reduction of short-term effects of inflation expectations on the price mechanism on the money market. Higher contribution of expected real interest rates to the nominal interest rates conditional variance also reduced distorting effects of money markets imperfections resulting from false price signals related to sudden inflation shifts.

Despite the absence of an apparent nominal anchor, explicit inflation targeting delivered similarly successful results in disinflation process in the group of countries, so called "floaters". Substantially higher role of the inflation expectations in this group of countries seemed to be reasonable. The overall impact of inflation expectations on nominal interest rates in the long-run mostly rose.

Overall effects of the crisis period related to the respective responses of nominal interest rates to the inflation expectations and expected real interest rates shocks seem to be puzzled. Redistributive impacts followed by increased asynchronous effects of local crisis are obviously associated with selective and irregular changes in expectations of agents though still well anchored by credible indicator. Economic crisis, as a typical exogenous shock and global phenomenon, affected economies especially through the external trade or/and financial flows channel, quickly spreading across a region of neighboring and interconnected economies. It seems to be convenient to expect that a relative importance of external nominal anchors during the crisis period became less successful in stabilizing inflation expectations, providing distorting effects of the crisis on the economy of anchoring country. However, our results indicates that a relative importance of inflation expectations in determining nominal interest rates generally decreased in the group of countries, so called "peggers". Even the price effects of economic crisis seem to be spurious and hardly predictable, a credible nominal anchor provided a crucial vehicle for stabilization of inflation expectations of agents, causing a relative drop in the role of inflation expectations in determining nominal interest rates during the crisis period.

Despite overall success of inflation targeting during the most of the 2000s we suggest that inflation expectations tend to suffer from low level of self-persistence and become quite

vulnerable to sudden changes caused by unexpected exogenous shocks in the group of countries, so called "floaters". Related nominal interest rates volatility and associated real interest rates instability reflected relatively low success of monetary authority to regain price stability proving the absence of a credible nominal anchor.

Acknowledgement

This paper was written in connection with scientific project VEGA no. 1/0973/11. Financial support from this Ministry of Education's scheme is also gratefully acknowledged.

References

1. BLANCHARD, O.J. - QUAH, D. (1988) *The Dynamic Effects of Aggregate Demand and Aggregate Supply Disturbances*, [National Bureau of Economic Research Working Paper No. 4637] New York, National Bureau of Economic Research, 39 p.
2. CALVO, G. - REINHART, C. (2002) *Fear of Floating*, Quarterly Journal of Economics 117(2): 379-408.
3. CROWDER, W.J. - HOFFMAN, D.L. (1996) *The Long-Run Relationship between Nominal Interest Rates and Inflation: The Fisher Equation Revisited*, Journal of Money, Credit and Banking, 28(1): 102-118.
4. DAMIAN, M. (2011) *The Comparative Analysis of the Monetary Policy Strategies before the Adoption of the Euro Currency and the Impact upon the Maastricht Criteria*, Journal of Applied Economic Sciences, 6(3): 222-229.
5. DEACON, M. - DERRY, A. (1994) *Estimating Market Interest Rate and Inflation Expectations from the Prices of UK Government Bonds*. [Bank of England, Quarterly Bulletin No. 34/1994], London, Bank of England, pp. 232-40.
6. ENGSTED, T. (1995) *Does the Long-Term Interest Rate Predict Future Inflation? A* Multi-Country Analysis. The Review of Economics and Statistics, 77(1): 42-54.
7. GARCIA, R. - PERRON, P. (1996) *An analysis of the real interest rate under regime shifts*, Review of Economics and Statistics, 78(1): 111–125
8. JOSIFIDIS, K. - ALLEGRET, J.P. - PUCAR, E.B. (2009) *Monetary and Exchange Rate Regime Changes: The Case of Poland, Czech republic, Slovakia and Republic of Serbia*, Panoeconomicus, 56(2): 199-226.
9. KITOV, O. - KITOV, I. (2012) *Inflation and Unemployment in Switzerland*. Journal of Applied Economic Sciences, 7(2): 141-156.
10. LAI, K.S. (2004) *On Structural Shifts and Stationarity of the Ex Ante Real Interest Rate*, International Review of Economics and Finance, 13(2): 217-228
11. LANNE, M. (2001) *Near unit root and the relationship between inflation and interest rates: A Reexamination of the Fisher effect*, Empirical Economics, 26(2): 357-366.
12. MIRDALA, R. (2012) *Sources of Exchange Rate Volatility in the European Transition Economies (Effects of Economic Crisis Revealed)*. Journal of Applied Economic Sciences, 7(3): 270-282.
13. MISHKIN, F. S. (1988) What does the Term Structure Tell us about Future Inflation. Journal of Monetary Economics, 25(1): 77-95.
14. NEELY, CH.J. - RAPACH, D.E. (2008) *Real Interest Rates Persistence: Evidence and Implications*, [Federal Reserve Bank of St. Louis, Review No. 6/2008] St. Louis, Federal Reserve Bank of St. Louis, 90(6): 609-641.
15. RAGAN, C. (1995) *Deriving Agents' Inflation Forecasts from the Term Structure of Interest Rates*. [Bank of Canada, Working Paper, No. 1/1995] Ottawa, Bank of Canada, 41 p.
16. ST-AMANT, P. (1996) *Decomposing U.S. Nominal Interest Rates into Expected Inflation and Ex Ante Real Interest Rates Using Structural VAR Methodology*, [Bank of Canada, Working Paper No. 2/1996] Ottawa, Bank of Canada, 28 p.
17. STRACHMAN, E. - FUCIDJI, J.R. (2012) *The Current Financial and Economic Crisis: Empirical and Methodological Issues*, Journal of Advanced Studies in Finance, 3(1): 95-123.